Simultaneity...

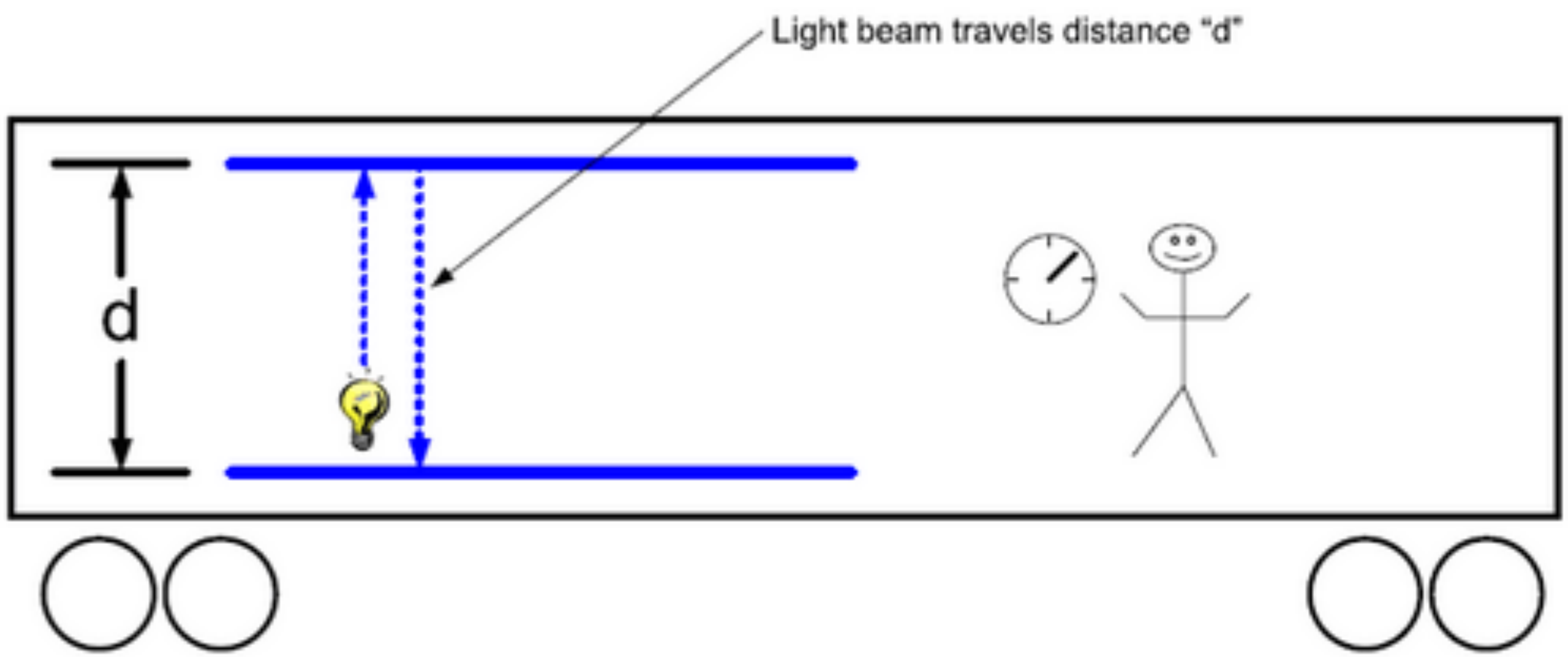
Imagine a train, moving close to the speed of light, with light-triggered doors on each end. A passenger activates a light in the middle of the carriage.

- The passenger will see the light travel to both doors at the same speed, and the doors open simultaneously.
- An external observer will see the light reach the back door much more quickly, and will not see them open simultaneously.

> The observation of simultaneity is dependent on the frame of reference

Time dilation

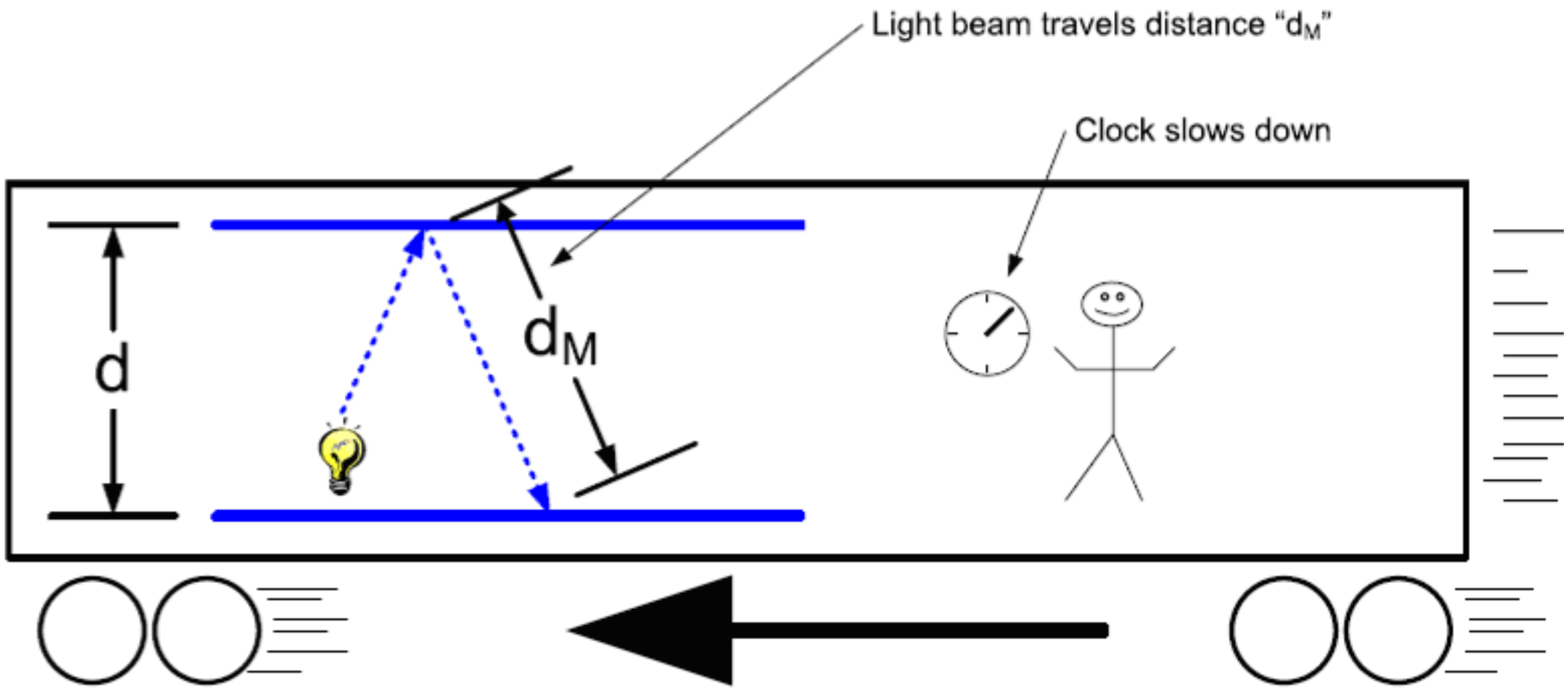
Imagine a light beam is sent from the floor of a train, reflected off a mirror on the roof and then detected again on the floor. The time taken for the light beam to return is measured.



A passenger inside the train sees the light travel vertically and measures the time taken.

http://blog.nerdworld.org/blog/2010/07/the-speed-of-light-time-dilation-a-quandary.html

An external observer sees the light travel diagonally (due to the motion of the train), and hence observes a longer time for the light travelling than the passenger.



The observation of time is dependent on the frame of reference

http://blog.nerdworld.org/blog/2010/07/the-speed-of-light-time-dilation-a-quandary.html

Quantifying

If we were to analyse the different path lengths which the light travelled (using pythagorus), we arrive at the following equation:

$$t_v = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Where t_0 is the time of an event in the reference frame where it happens, and t_v is the time of the same event observed from a reference frame moving at velocity v relative to the event (and c is the speed of light).

Note:

All the equations for special relativity use this idea of a rest frame and moving frame (of reference):

- The rest frame is the one in which the observer is stationary with respect to the measurement. It has the subscript *0*.
- The moving frame is when the observer is moving with respect to the measurement. It has the subscript *v*.